



March 3, 2015

Via Electronic Filing

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street S.W.
Washington, D.C. 20554

Re: *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Docket No. 12-354

Dear Ms. Dortch:

Google has consistently supported the use of interconnected spectrum access systems (SASs) to manage coexistence between incumbent users, Priority Access (PA) users, and General Authorized Access (GAA) users in the 3.55 GHz band.¹ Interconnected SASs will enable robust spectrum utilization, while competition among SAS providers will encourage innovation in SAS services and products, including methods that free additional spectrum for productive shared use. Google therefore supports CTIA's recent ex parte filing to the extent it proposes that wireless carriers, among others, be permitted to operate SASs.²

CTIA's overall recommendations, however, threaten to fragment the management of shared 3.55 GHz spectrum in a way that both reduces protection of incumbent systems and limits opportunities for sharing unused PA spectrum. In particular, CTIA appears to be suggesting that (1) devices may rely on spectrum sensing alone, rather than SAS management, and (2) service providers should not be required to exchange information about the usage of Citizens Band Radio Service (CBRS) devices on their networks.³ Accepting either of these premises would greatly compromise utilization of the 3.55 GHz band. A SAS cannot provide adequate

¹ See, e.g., Comments of Google Inc., GN Docket No. 12-354, at 18 (Feb. 20, 2013); Comments of Google Inc. on the Proposed Revised Framework, GN Docket No. 12-354, at 12-13 (Dec. 5, 2013); Reply Comments of Google Inc. on the Proposed Revised Framework, GN Docket No. 12-354, at 8 (Dec. 20, 2013); Comments of Google Inc. on the Further Notice of Proposed Rulemaking, GN Docket No. 12-354, at 32 (July 14, 2014).

² Letter from Scott Bergman, Regulatory Affairs Vice President, CTIA-The Wireless Association, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-354 (Jan. 12, 2015) (CTIA Ex Parte Letter).

³ *Id.*, Attach. at 3 (referring to SASs as an "optional" part of a managed system).

protection if it lacks information necessary to calculate interference based on the aggregation of all commercial users. If such information were not made available to and shared among SASs, worst-case assumptions would need to be made and separation distances will have to be increased dramatically. This would substantially reduce the utility of the 3.55 GHz band, while reducing the value of this proceeding as a catalyst for improved spectrum-sharing practices and technologies.

CTIA's recommendations also raise concerns about warehousing of spectrum. In this proceeding, the Commission seeks to "drive greater productivity and efficiency in spectrum use" through spectrum sharing technologies.⁴ As a result, the Commission has expressed a clear preference for promoting intensive shared use and has proposed both technology and policy levers to "discourag[e] [spectrum] warehousing."⁵ If information regarding actual use by PA licensees could be withheld from the SASs, entities could easily prevent other operators from using the shared resource by reserving PA spectrum, failing to use it, and failing to disclose their non-use.

Finally, CTIA's recommendations should be rejected insofar as the association urges tolerance for equipment that cannot operate across the entire CBRS band—as is necessary to accommodate all spectrum reassignments that could be needed to protect against impermissible interference. In order to maximize spectrum utilization, the Commission should hold to its proposed rule requiring that all CBRS devices—whether PA or GAA—are capable of operating throughout the band.⁶

1. Protecting Incumbent Users Requires Aggregation Calculations, Which in Turn Requires SASs to Have Information Regarding All PA and GAA Users.

The Commission has recognized that adequate interference protection for incumbents, consistent with the PCAST Report's central principle that secondary users must accept interference from primary users, requires taking into account the aggregate effects of deploying multiple PA or GAA devices.⁷ In its Further Notice of Proposed Rulemaking (FNPRM), the Commission states that

[in order t]o perform proper frequency assignments and interference management, it is important for the SAS to have a baseline threshold for

⁴ *In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Further Notice of Proposed Rulemaking, 29 FCC Rcd. 4273, ¶ 3 (2014) (FNPRM).

⁵ Public Notice, *Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band*, 28 FCC Rcd. 15,300, ¶¶ 24, 33 (2013).

⁶ FNPRM ¶ 64, App. A, §96.36(b).

⁷ FNPRM ¶ 79; Executive Office of the President, President's Council of Advisors on Science and Technology, *Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, Report to the President, at 8-9, 111 (July 2012) (PCAST Report).

the maximum signal level from [Citizens Band Service Devices (CBSDs)] at the border of their service area. Therefore, Citizens Broadband Radio Service users should ensure that the aggregate signal level from their CBSDs as well as transmissions from their associated End User Devices at the edge of their authorized service areas remain at levels that would not harm other CBSDs in the same or higher tiers.⁸

The same protection assurance is needed to protect incumbent users, such as federal systems and in-band fixed satellite service (FSS) receivers, and adjacent-band FSS receivers.

At the Commission's workshop in January 2014 and in subsequent presentations, Google has demonstrated that aggregation can be accomplished readily and scalably with current cloud computing technology that is widely available to potential SAS providers.⁹ In the presentation to the Commission earlier this year, we demonstrated aggregated protection for all C-Band FSS sites registered with the FCC. And the technical work needed to support SAS-to-SAS coordination and information sharing is underway in an industry group organized by the Wireless Innovation Forum. The group includes broad participation by the mobile broadband providers, infrastructure providers, and SAS providers.¹⁰

A slide presented by Google at the January 14, 2014, workshop illustrates the need to account for aggregate interference.

⁸ FNRPM ¶ 79.

⁹ See FCC, 3.5 GHz Spectrum Access System Workshop, Jan. 14, 2014, <http://www.fcc.gov/events/35-ghz-spectrum-access-system-workshop>; Preston Marshall, *Spectrum Access System: Managing Three Tiers of Users in the 3550-3700 GHz Band* (Jan. 14, 2014) (Marshall Presentation), available at http://wireless.fcc.gov/workshops/sas_01-14-2014/panel-1/Marshall-Google.pdf; Letter from Austin C. Schlick, Director, Communications Law, Google, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-354 (Jan. 20, 2015).

¹⁰ See *Wireless Innovation Forum Announces Approval of New Spectrum Sharing Committee: New Committee to Act as Common Industry and Government Standards Body for Proposed U.S. 3.55 GHz Band Rulemaking Activities and Other Future Spectrum Sharing Opportunities*, Business Wire, Feb. 12, 2015, <http://www.businesswire.com/news/home/20150212006167/en/Wireless-Innovation-Forum-Announces-Approval-Spectrum-Sharing#.VOzp7MYqkho>.

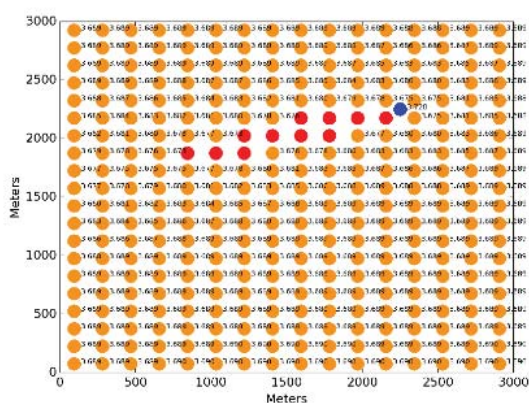
SAS Enables Aggregation Protection

Without aggregation

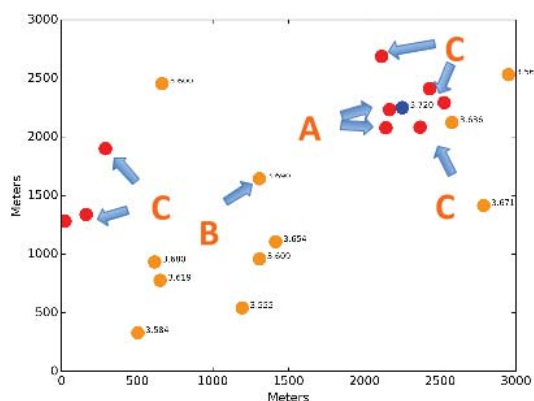
- Using same C-band example, the out of band emissions from a single, individual node would be acceptable in any orange position.
- Only nodes in red positions would be precluded.

Accounting for aggregation

- A** nodes would not have been valid, even singly.
- Node **B** consumed most of the incumbent out-of-band interference tolerance, so **C** nodes are excluded, protecting the primary user.



Assumptions: 0.1 I/N threshold, 5 degrees elevation



In this slide, the blue dot represents an FSS earth station; the orange dots on the left side represent locations where any individual CBSD could comply with proposed interference limits to FSS operations; and the red dots represent areas where no secondary operations would be permitted. The image on the left represents the visibility of a SAS viewing only individual CBSDs in isolation or viewing only a subset of deployments. The image on the right shows a series of assignments in the band, taking into account the aggregation of interference effects by multiple devices. As devices randomly enter the band in proximity of the FSS site, several effects can be noted: (1) The A nodes should always be rejected because even individual nodes would cause interference in those areas. The B node enters the band early and is granted access. This node does emit power that is received at the location of the earth station, but that received power falls below the harmful interference threshold. However, a SAS must ensure that entry of later C nodes does not cause aggregate power to exceed the limit. The C nodes would have been permitted to enter on a standalone basis, but when combined with the energy being emitted by the B node, the aggregate interference level becomes harmful. While aggregate interference considerations will not necessarily constrain use of the 3.55 GHz band in actual practice, a SAS must account for aggregation in order to provide adequate interference protection.

To enable SASs to calculate aggregate interference effects accurately, the FCC should hold to its proposal that all PA and GAA users must share information regarding their operations with a SAS, and require all SASs to share that information with each other.¹¹ In an exclusive use band, a single organization can manage spectrum with knowledge of only its own needs and operations. But in a shared environment, each device may have an impact on other users, whether by contributing to adjacent band interference to primary operations, aggregate out-of-band emissions into adjacent users, or aggregate interference into in-band incumbents. Determining whether any of these types of interference will occur requires awareness of the full extent of actual deployments. This can be accomplished only if SAS providers have full information about the actual locations and maximum operating parameters of all CBRS devices.

If SASs lack the ability to determine the aggregate number of CBRS devices operating in the vicinity of incumbents and the characteristics of those devices, then protection criteria must be altered to account for this unnecessary uncertainty. Worst case possibilities, rather than real-world utilization, would drive spectrum assignments, and spectrum that could be available for use would lie fallow. The Commission can and should avoid this result by requiring information sharing by spectrum users and SASs.

2. Information Sharing Improves Network Planning and Discourages Warehousing

Information sharing via a SAS also increases spectrum utilization by allowing PA and GAA operators to plan their networks more effectively, and by discouraging warehousing.

Awareness of other operations in the band will facilitate effective network planning for all users of the 3.55 GHz band. PA users can discern which channels are in use in particular locations, and design their own future deployments to avoid those frequencies and places. Similarly, GAA users can determine where GAA spectrum is available and take that information into account when considering whether and where to invest in deploying services that will not be able to claim interference protection.

Moreover, transparency regarding the exact locations of actual CBRS deployments will discourage warehousing. By comparing devices deployed to PA licenses held, the FCC and other interested parties can determine whether and to what extent licensees are making use of their reservations, and GAA users can be allowed into the vacant spectrum until the license holder is ready to assert its rights. Without such transparency, PA licensees might claim exclusionary rights to spectrum that they are not in fact using, unnecessarily limiting non-interfering GAA uses.

¹¹ See FNPRM ¶ 63 (“For the SAS to predict and evaluate potential interference and spectrum availability accurately it must have accurate location information for *all* CBSDs.”) (emphasis added).

3. Information Sharing Among All Users Is a Predicate to Shared Operations in the Band

Finally, all users of the 3.55 GHz band must accept that some level of information sharing will be required to make spectrum sharing possible. As the Commission has recognized, shared use has the potential “to transform the availability of a precious national resource—spectrum—from scarcity to abundance.”¹² Sharing, though, will be possible only if users have enough information about other users’ operations in the band to manage coexistence.¹³

Incumbent users of the 3.55 GHz band are doing their part. The Department of Defense (DOD), in collaboration with the FCC, the Department of Commerce, and industry representatives, has been working to ensure that DOD use of the band is protected through sufficient information sharing, without compromising national security concerns about knowledge of DOD operations. Similarly, operators of FSS dishes must register the location of their dishes in the SAS in order to protect those operations. And the locations of WISP operations in the 3650-3700 MHz band are available through the FCC’s Universal Licensing System.

When a commercial user accepts the opportunity to share spectrum as a PA or GAA provider, it likewise must accept the obligation to provide the information other users need to maximize their use of the available spectrum. Sharing is a reciprocal arrangement between all users of the resource, not a unilateral entitlement. Thus, PA and GAA users should be required to share basic deployment information if they wish to take advantage of the shared resources available in the 3.55 GHz band. If a carrier, or other potential provider, is unwilling to participate in this mutually beneficial information sharing, then exclusively licensed spectrum is a more appropriate option for its network deployment.

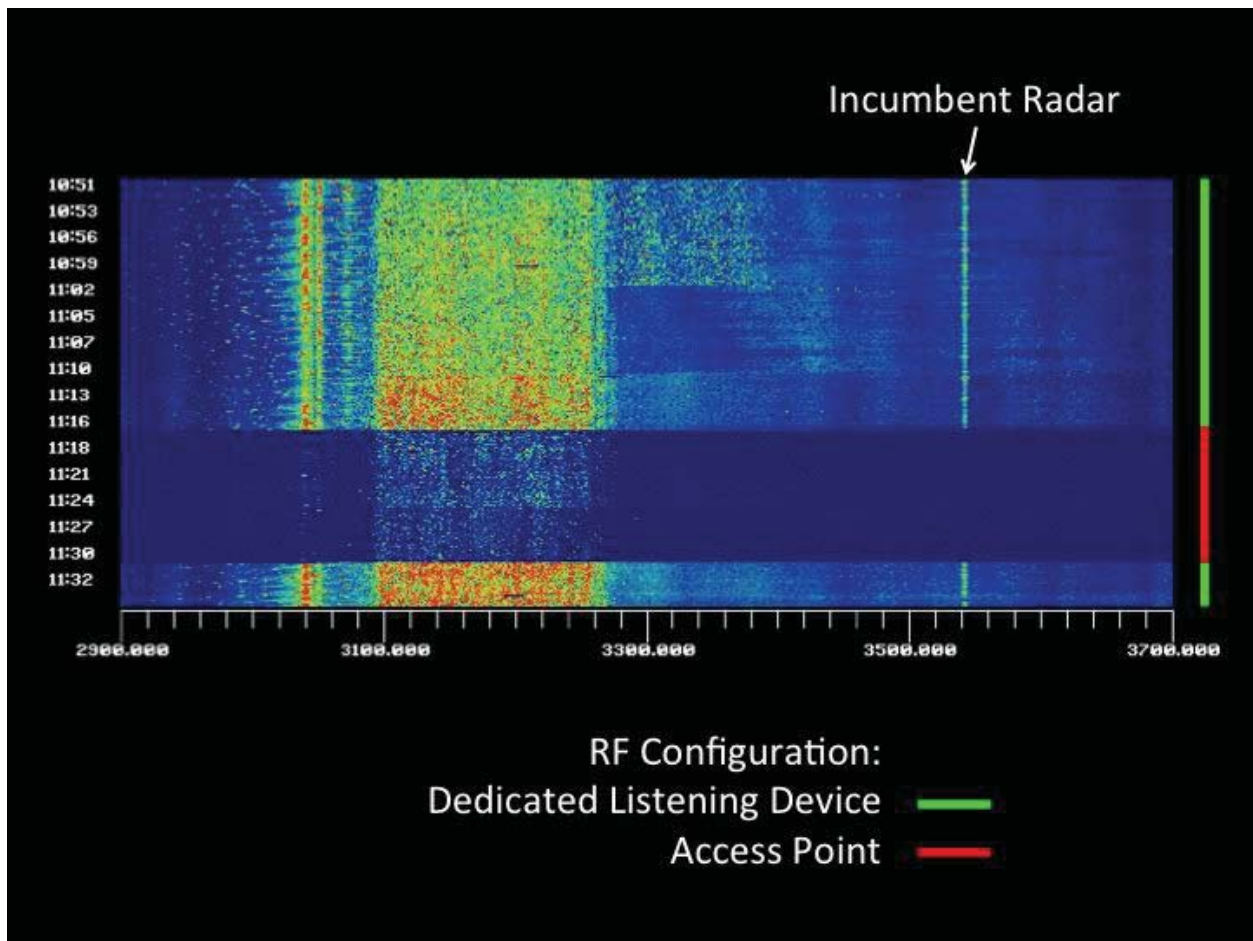
4. An Access Point Sensing-Only Solution Has Additional Drawbacks.

CTIA’s proposal that mobile broadband providers be allowed to deploy proprietary sensing systems without sharing information regarding their own use of the band should be rejected for the reasons just given. But even if protection based on aggregate interference was not required, in-network sensing could still be inadequate to protect incumbent users. For example, an access point may not be able to detect the presence of incumbent operations and therefore would instruct a client device outside the building that it is safe to transmit. The client device outside could then cause

¹² FNPRM at ¶ 2 (citing PCAST Report at vi and 17-20).

¹³ Disclosure of anonymous information about the location and characteristics of 3.55 GHz access points raises no privacy concerns, just as neither cellular carriers’ published network maps, nor registrations of wireless microphones in the TV white space databases, compromise user privacy.

interference to higher-tier users in proximity to the device. The use of optimally positioned dedicated listening devices, in combination with a SAS, avoids these risks. The chart below illustrates this point.



This waterfall plot compares the capability of Dedicated Listening Device (DLD) equipment that is correctly positioned to listen for incumbent signals, with the capability of representative access point equipment to detect incumbent activity. It reports actual detection from a beachfront building in the Norfolk, Virginia, area. The x-axis shows frequency, and the y-axis shows time. The colors inside the plot correspond to received signal strength: dark blue represents a weak signal, while red and bright green represent strong signals. The incumbent radar is the strong vertical line near 3540 MHz, while other activity in the spectrum is caused by adjacent-band radars. From 10:51 until approximately 11:16, the data were obtained using a DLD configuration, including an outdoor directional antenna and high-performance, low-noise amplifier.

From 11:16 until approximately 11:31 (a time period highlighted by the red bar to the right of the plot), the outdoor antenna and amplifier were detached and an L-Com model HG3505RD-RSP antenna, a typical 3.5 GHz access point antenna, was connected directly to the spectrum analyzer. The access point antenna and spectrum analyzer were placed in a window directly overlooking the ocean in a tenth-story room, just a few feet from the outdoor DLD antenna. Despite the very favorable conditions, the access point configuration was unable to detect the incumbent radar: this is represented by the break in the received radar signal between 11:16 and 11:31. At 11:31, the DLD configuration was reattached, and the incumbent radar activity was again detected. These data demonstrate that even under favorable conditions, a representative access point configuration was unable to detect incumbent activity.

Moreover, the “blanking” approach proposed by CTIA depends on all users in the band being quiet at the same time while devices listen for the presence of incumbent operations. It therefore will only work if all CBRS devices in the same area are time-synchronized.¹⁴ The approach will not work if, for example, a GAA WISP does not employ the same time-synchronization technique as, say, LTE networks with in-network sensing. In such a circumstance, the WISP might transmit during the time when LTE devices are listening for an incumbent signal, causing confusion as to whether incumbents are indeed present in the band.

To be clear, Google is not advocating that the FCC mandate a specific kind of sensing technology to ensure incumbent protection. Rather, all sensing solutions should adequately protect incumbents in the 3.55 GHz band without requiring users to adopt a specific technology.

5. In Order to Maximize Utilization of the 3.55 GHz Spectrum, the Commission Should Require All CBRS Devices to Operate Across the Entirety of the Band

Because incumbents’ use of the 3.55 GHz band varies throughout the country, there will be times and places where particular channels within the band are unavailable. In order to ensure that the spectrum is fully utilized even if particular channels are occupied, the Commission should require all GAA and PA devices to operate across the entire 150 MHz of spectrum between 3550 and 3700 MHz. This capability is critical to avoid devices becoming “stranded” and unusable when federal incumbents preempt commercial use of portions of the band (creating burdens on federal and commercial users alike). In particular, there would be less chance of controversy when commercial users are required to relocate their operations to different spectrum in order to protect federal incumbents. Operability across the full band will also be beneficial where PA licenses are not renewed, because equipment intended for those networks can be put to other uses. Without this flexibility, investments in

¹⁴ CTIA Ex Parte Letter, Attach. at 5.

deployed infrastructure and devices would be at greater risk. For these reasons, the Commission should, as it proposes,¹⁵ adopt a rule that requires all CBRS devices to operate throughout the full band.

Moreover, devices should be able to operate in the 3.55 GHz band without reliance on any other band for operation. While Google does not oppose devices using this band in conjunction with other frequencies (e.g., relying on unlicensed frequencies at 2.4 GHz and 5 GHz as well as GAA, or relying on licensed frequencies in addition to PA), device operation should not be dependent on the use of other bands. (In the case of LTE, this implies all LTE devices certified by the Commission for the band would be required to support the standalone modes for Band 42 and Band 43 in this spectrum, as adopted by 3GPP.) This approach will ensure that a diversity of users and providers can make use of this spectrum.

* * * * *

The Commission has the opportunity to free significant 3.55 GHz spectrum for commercial use as well as advance spectrum sharing techniques. But the Commission's success is predicated on adequately protecting incumbent operations. The Commission should adopt rules that ensure accurate protection of incumbents.

Sincerely,



Aparna Sridhar
Counsel

cc: *Via electronic mail*
John Leibovitz

¹⁵ FNPRM at ¶ 64.